THE INFLUENCE OF LIGHT AND TEMPERATURE ON FAT UTILIZATION IN FEMALE *CLEMMYS INSCULPTA*[1, 2]

FRED J. BRENNER

Biology Department, Grove City College, Grove City, Penna. 16127

ABSTRACT

Laboratory populations of female *Clemmys insculpta* were subjected to different conditions of light at two environmental temperatures to assess their influence on fat utilization, as well as on the reproductive condition of the species. Both light and temperature affected the rate of fat utilization in muscle, but not in the liver. However, a variation did occur in the fat content in all three tissues of animals exposed to different light and temperature conditions. A positive correlation existed between ovarian fat content and maturation of the ova.

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INTRODUCTION

A relationship exists between the fat cycle and the different phases of the life histories of vertebrates, especially with hibernation, migration, and reproduction. Several authors have demonstrated a correlation between the fat cycle and the reproductive conditions of different classes of terrestrial vertebrates, i.e.: for amphibians, Brenner (1966), Brenner and Brenner (1969), Bush (1963), Rose (1967), and Rose and Lewis (1968); for reptiles, Hahn and Tinkle (1965), Volsøe (1949), Tinkle (1962), and Wharton (1966); and for birds, Brenner (1967, 1968). The current study concerns the role of light and temperature on the amount and pattern of fat utilization, as well as its possible relationship to ovarian development, in the turtle, *Clemmys insculpta*.

METHODS

Forty-four female turtles, eight to nine inches in carapace length, were obtained from a commercial dealer in mid-September and maintained under conditions of natural daylight and temperature for one month prior to the initiation of these experiments. Twelve of these turtles were then removed and sacrificed by snapping the spinal cord. The remaining 32 turtles were divided into four equal groups and maintained in individual containers without food at four different environmental conditions for a 120-day period: (1) L/RT: natural daylight at an average temperature of 23 ± 0.21°C; (2) D/RT: complete darkness at an average temperature of 21 ± 0.25°C; (3) L/C: eight hours of light at an average temperature of 5 ± 0.13°C; and (4) D/C: complete darkness at an average temperature of 5 ± 0.21°C.

Samples (5–8 g) of the liver, of the ventricle of the heart, of the extensor femoralis muscle, and of the right ovary were removed from 12 individuals at the initiation of the experiment, as well as from 2 individuals removed at random from each environmental condition at 30-day intervals. The amount of fat in the various tissues was determined, immediately upon their removal from the animals, by the method described by Brenner and Malin (1965). Samples were weighed to within ± 0.1 mg, dried at 70°C until no further weight loss occurred, usually 24 hours, and then placed in petroleum ether for 24 hours to extract the fat. The difference between the dry weights before and after extraction was used as the amount of ether-soluble extract (fat) present in the sample.

RESULTS AND DISCUSSION

Light and temperature influenced the fat content, as well as the rate of fat utilization in skeletal muscle. The skeletal muscle of turtles exposed to room temperature and to light or dark conditions had significantly more fat than did those exposed to similar conditions at 5°C ($P < 0.01$) (Table 1). In this regard,

TABLE 1

The percent fat in different tissues of female Clemmys insculpta *exposed to different environmental conditions*

Condition	Number	Percent Fat in Tissues					
		Skeletal Muscle		Cardiac Muscle		Liver	
		Mean	S.E.*	Mean	S.E.	Mean	S.E.
Initiation	12	13.6	± 1.7	8.3	± 0.3	36.7	± 3.5
L/RT	8	11.3	± 3.9	4.7	± 1.8	32.5	± 8.8
D/RT	8	11.5	± 3.4	7.0	± 1.4	20.0	± 5.3
L/C	8	5.7	± 2.2	6.0	± 1.9	32.1	± 7.1
D/C	8	0.8	± 0.3	2.8	± 0.9	30.8	± 7.6

*S.E.—Standard error.

turtles exposed to total darkness at 5°C had significantly less skeletal muscle fat than did those exposed to eight hours at 5°C; however, a similar phenomenon did not occur in turtles exposed to light and dark conditions at room temperature ($P>0.50$). The rate of fat utilization from the skeletal muscle was significantly less in turtles maintained at 5°C under both light and dark conditions than was the rate in those maintained under similar conditions at room temperature ($P<0.01$) (fig. 1). However, the rate of fat utilization from the skeletal muscle of turtles maintained under conditions of natural daylight at room temperature was the same as those maintained under similar conditions in complete darkness ($P>0.50$). There was a similar rate of fat utilization in these tissues of turtles maintained at 5°C under light and dark conditions ($P>0.30$).

The cardiac tissue of turtles exposed to dark conditions at room temperature (21°C) had significantly more fat than did that of turtles exposed to a similar

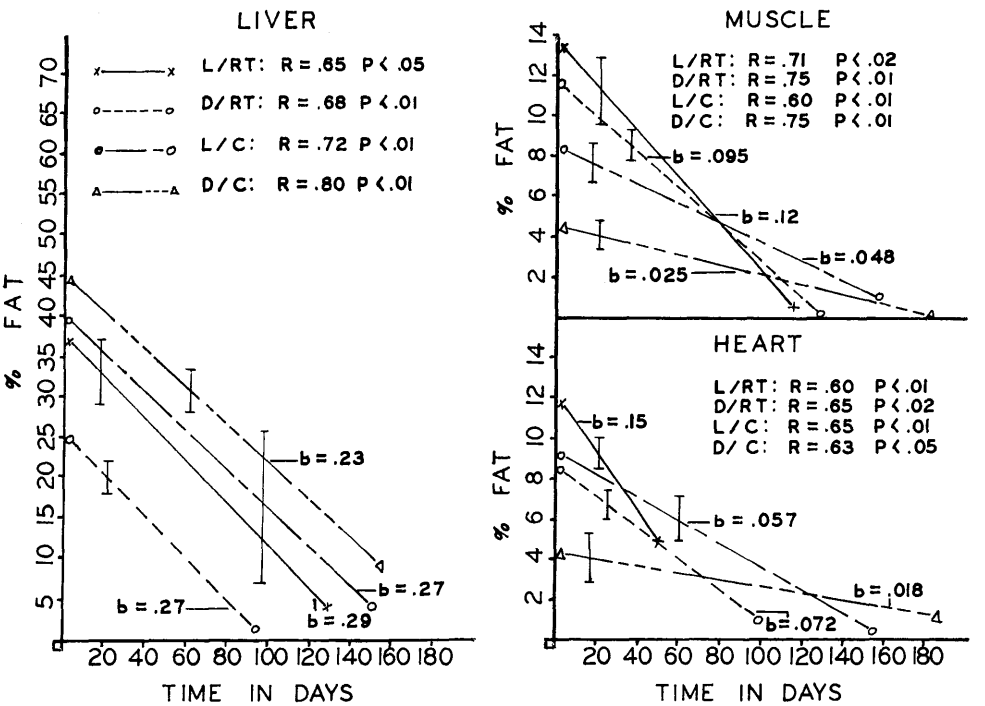

FIGURE 1. The rate of fat utilization in three tissues of female *Clemmys insculpta* during exposure to four environmental conditions.

condition at complete darkness and at 5°C ($P<0.01$). However, the fat content of the heart tissue was the same among turtles exposed to all other environmental conditions ($P>0.30$).

In regard to fat utilization in the cardiac muscle, turtles exposed to natural daylight and room temperature utilized cardiac fat at a significantly greater rate than did those exposed to a similar temperature with complete darkness ($P<0.02$), or than did those exposed to 5°C under both light and dark conditions ($P<0.01$). Likewise, there was a significant difference in fat utilization between turtles exposed to complete darkness at room temperature and those exposed to complete darkness at 5°C ($P<0.05$). On the other hand, the rate of fat utilization from the cardiac tissue was the same in turtles exposed to conditions of complete darkness and room temperature as it was in those exposed to eight hours of light and 5°C ($P>0.40$).

The fat content of the liver was significantly less in turtles exposed to complete darkness and room temperature than it was in those exposed to the other three environmental conditions ($P<0.01$). However, the rate of utilization of fat in the liver of these turtles was similar under all other environmental conditions ($P>0.50$).

Turtles utilized the fat from cardiac and skeletal muscle at a similar rate under all environmental conditions ($P>0.40$). On the other hand, the utilization of fat from liver tissue increased significantly as compared with the utilization of fat from both cardiac and skeletal muscle in all environmental conditions ($P<0.001$).

The amount of ovarian fat was correlated with the maturation of ova (fig. 2) and increased significantly with the increase in ovarian weight ($P<0.001$). Ovarian

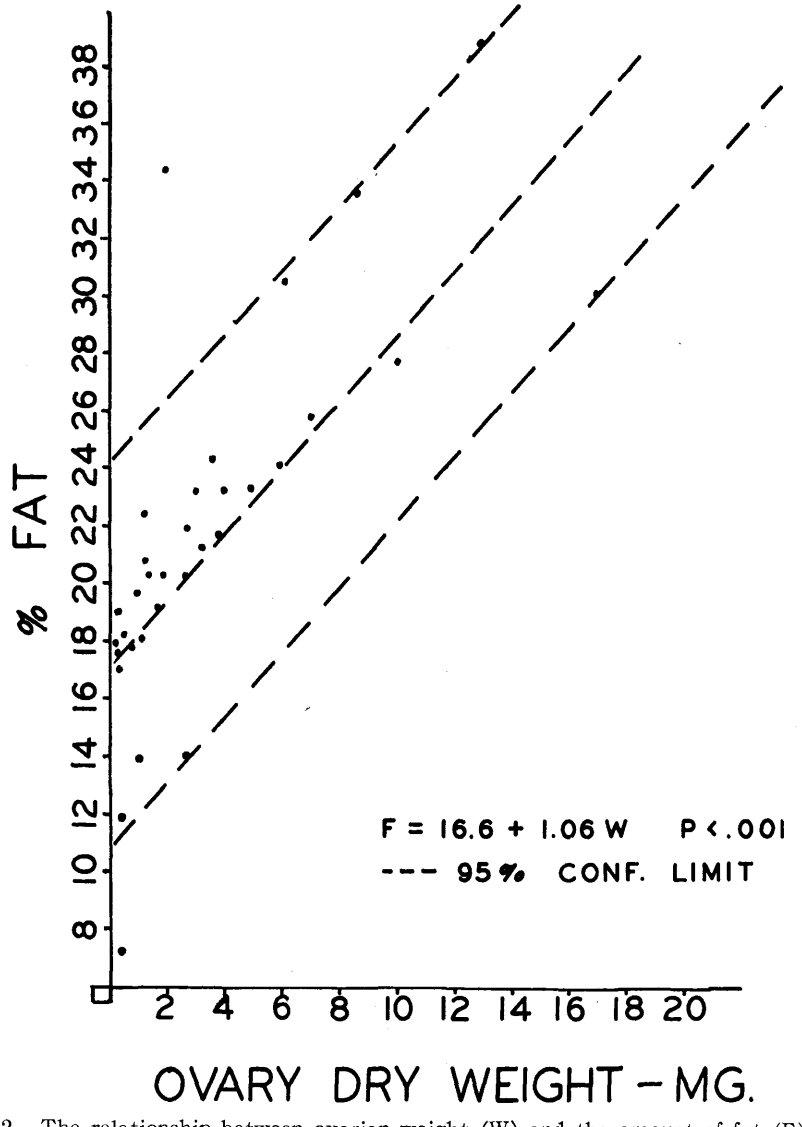

FIGURE 2. The relationship between ovarian weight (W) and the amount of fat (F) in the ovaries of 42 female *Clemmys insculpta*.

fat increased regardless of the corresponding decrease in the fat content of the other tissues sampled during the 120-day exposure to the different environmental conditions. In this regard, an inverse relationship between body fat and gonadal weight has been reported for several groups of ectothermic vertebrates (Tinkle, 1962; Bush, 1963; Rose, 1967; Rose and Lewis, 1968). Hahn and Tinkle (1965) suggested that the fat bodies of *Uta stansburiana* might be depositories for the various micro-nutrients involved in vitellogenesis. In this regard, Rose and Lewis (1968) found a direct correlation between the rates of fat-body depletion and of ovarian development in paedogenic *Ambystoma tigrinum*, and a similar phenomenon exists in *Clemmys insculpta*. Hence, photoperiod and temperature alter the amount and utilization of fat, as well as being correlated with the reproductive cycle of the species.

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